

Measurement and Compensation of Micromechanics in CW-Operated TESLA Type Cavities

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Why is microphonics an issue?

Energy Recovery Linacs:

- Beam loading small / close to zero
- Cavity run at high loaded Q
- Small cavity bandwidth

→ Any small shift in the cavity frequency

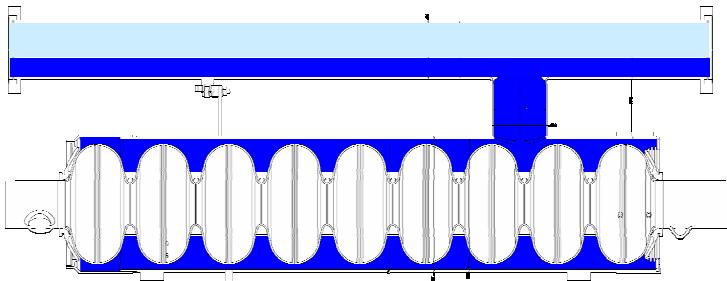
- requires significant increase in power to maintain constant field
- produces phase errors that affect the beam.

→ Must understand what microphonics should be expected

→ Must investigate mechanics of the cavity-tuner system to be able to compensate for the microphonics

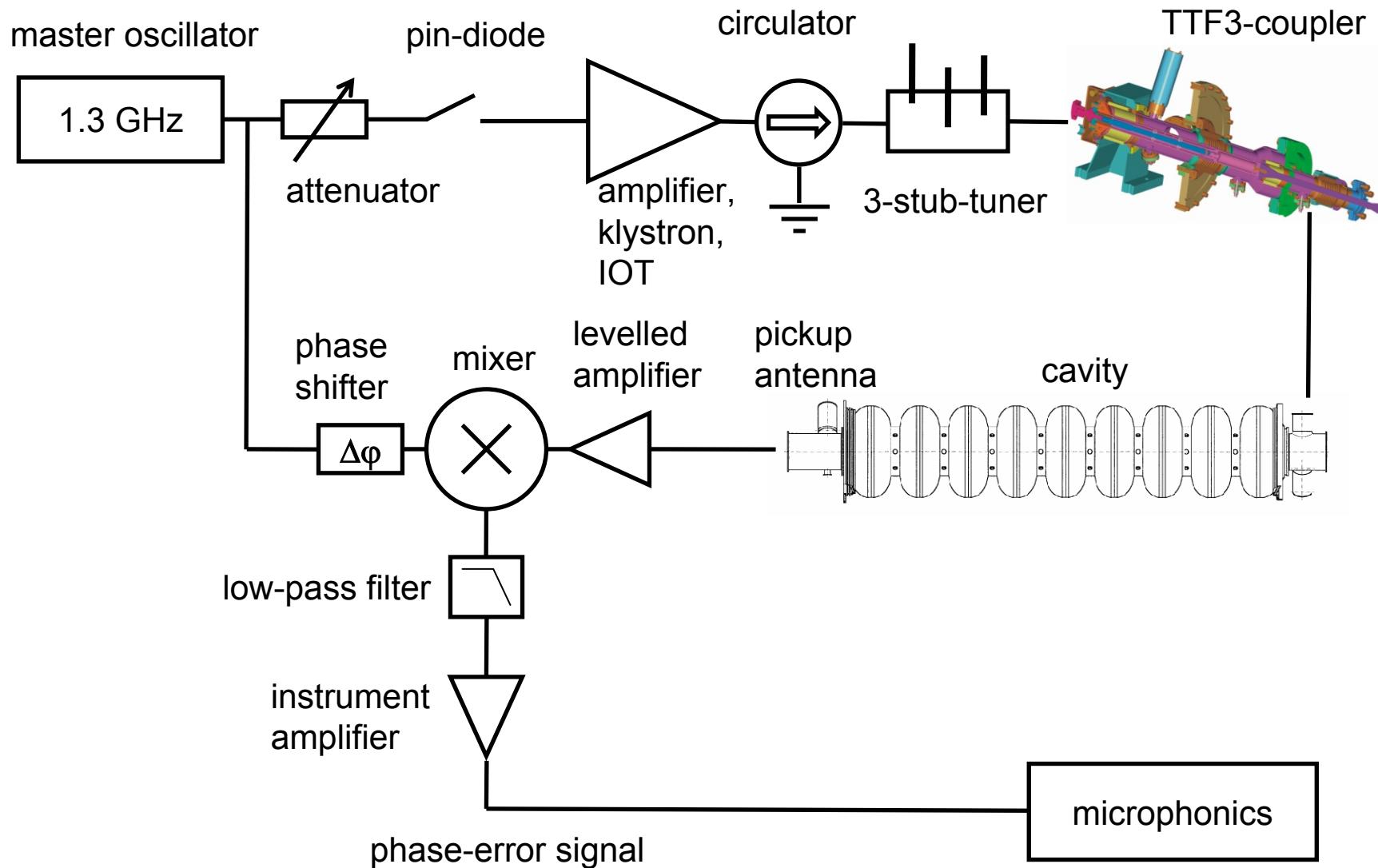
1. Experimental setup at HoBiCaT
2. Microphonics measurements
3. Comparison of tuner systems
4. Microphonics compensation
5. Conclusion

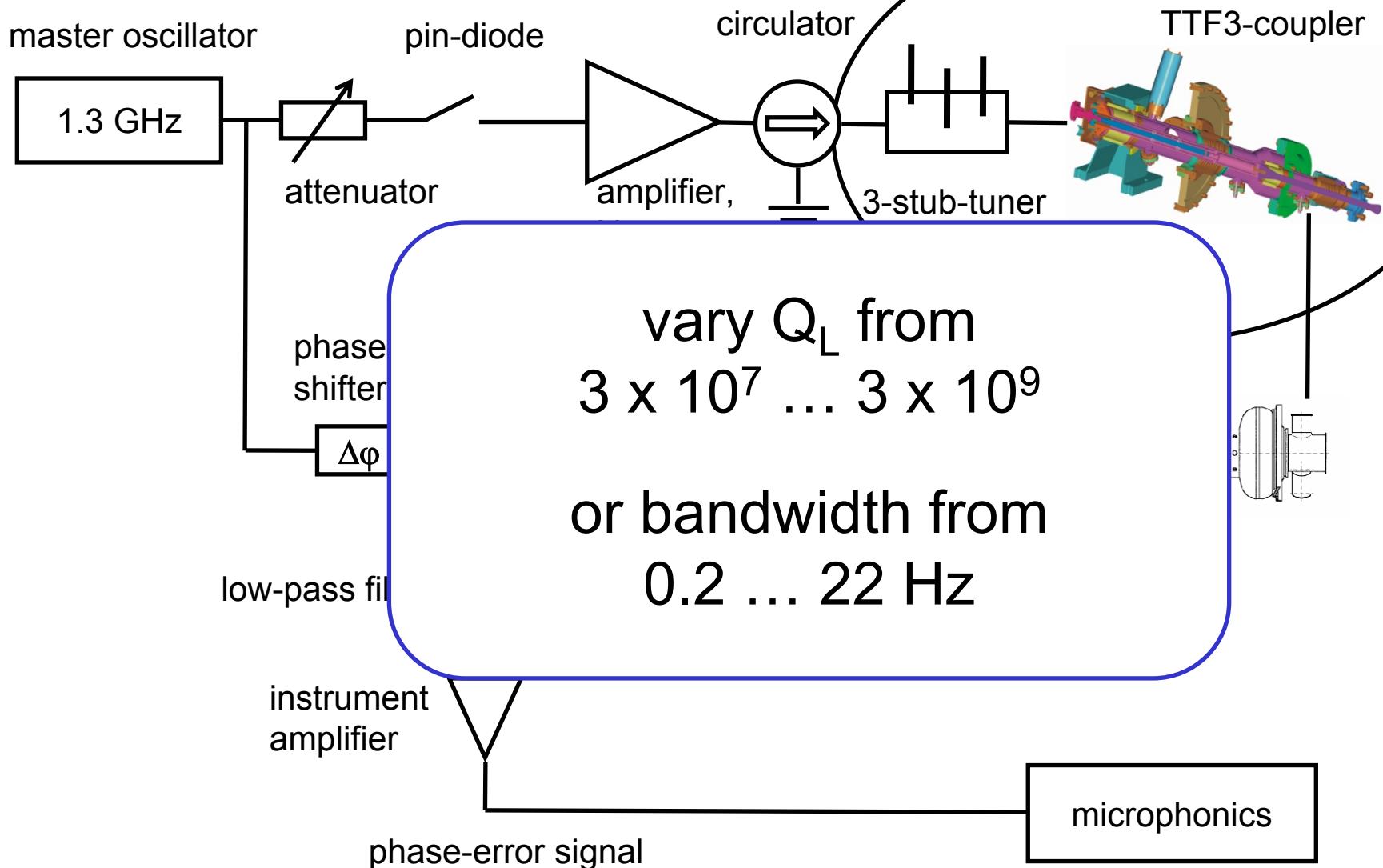
Purpose:
CW adaptation of TESLA technology

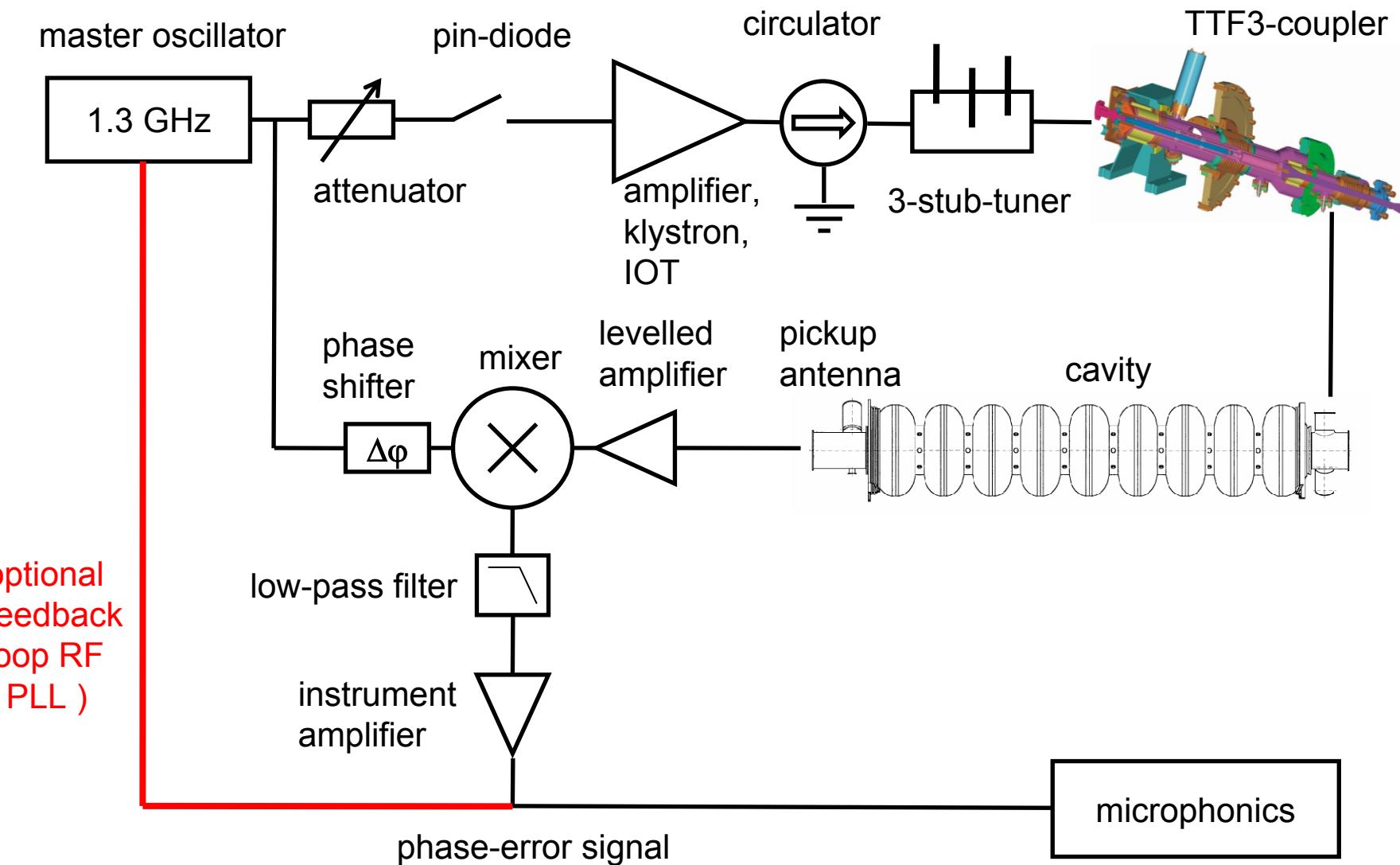


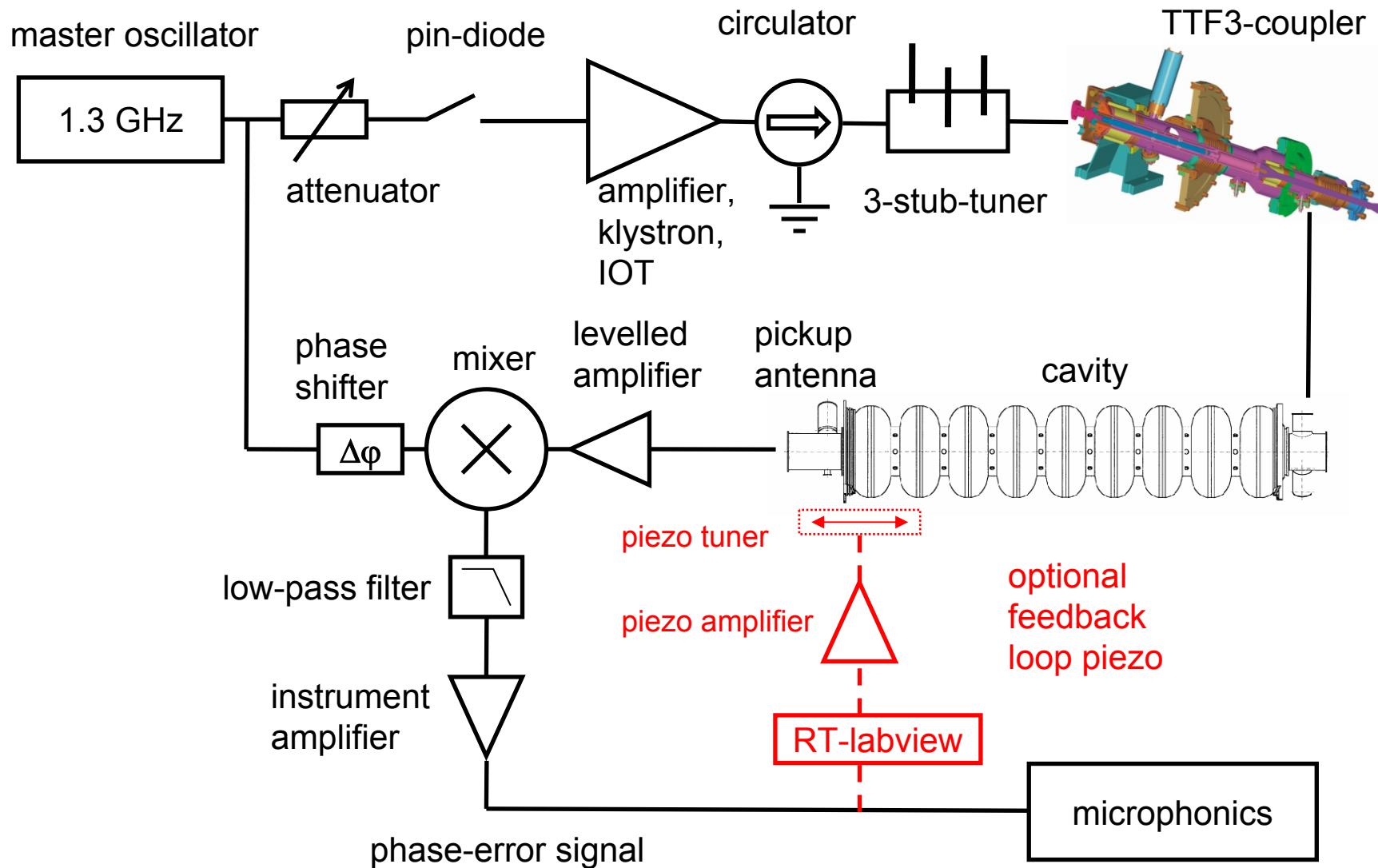
- Cryostat for two cavities
- Cryogenics 80 W @ 1.8 K
- 10 kW Klystron
- 30 kW IOT CW transmitter
- Low level-RF
- 4 different cavities tested so far



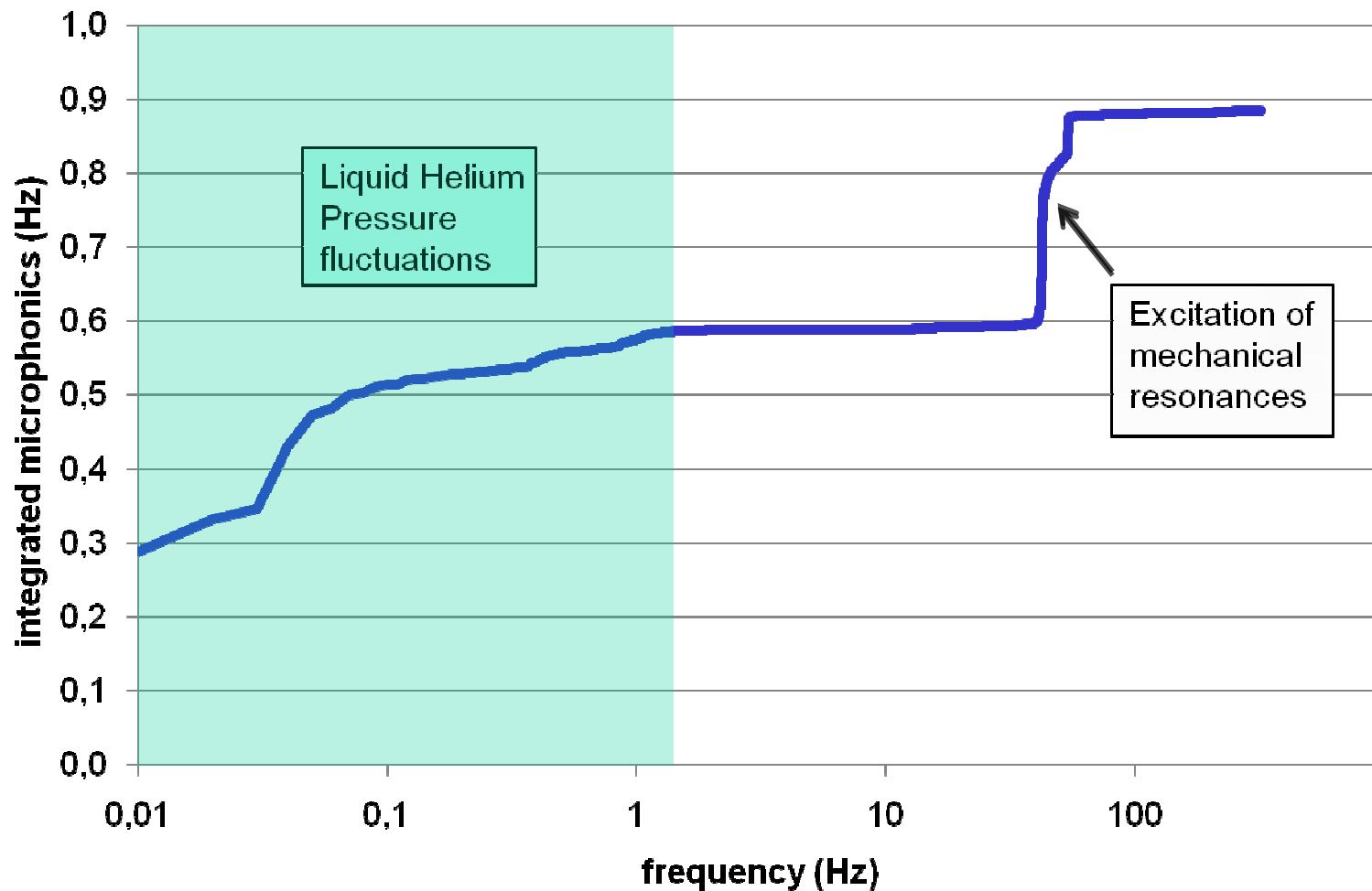




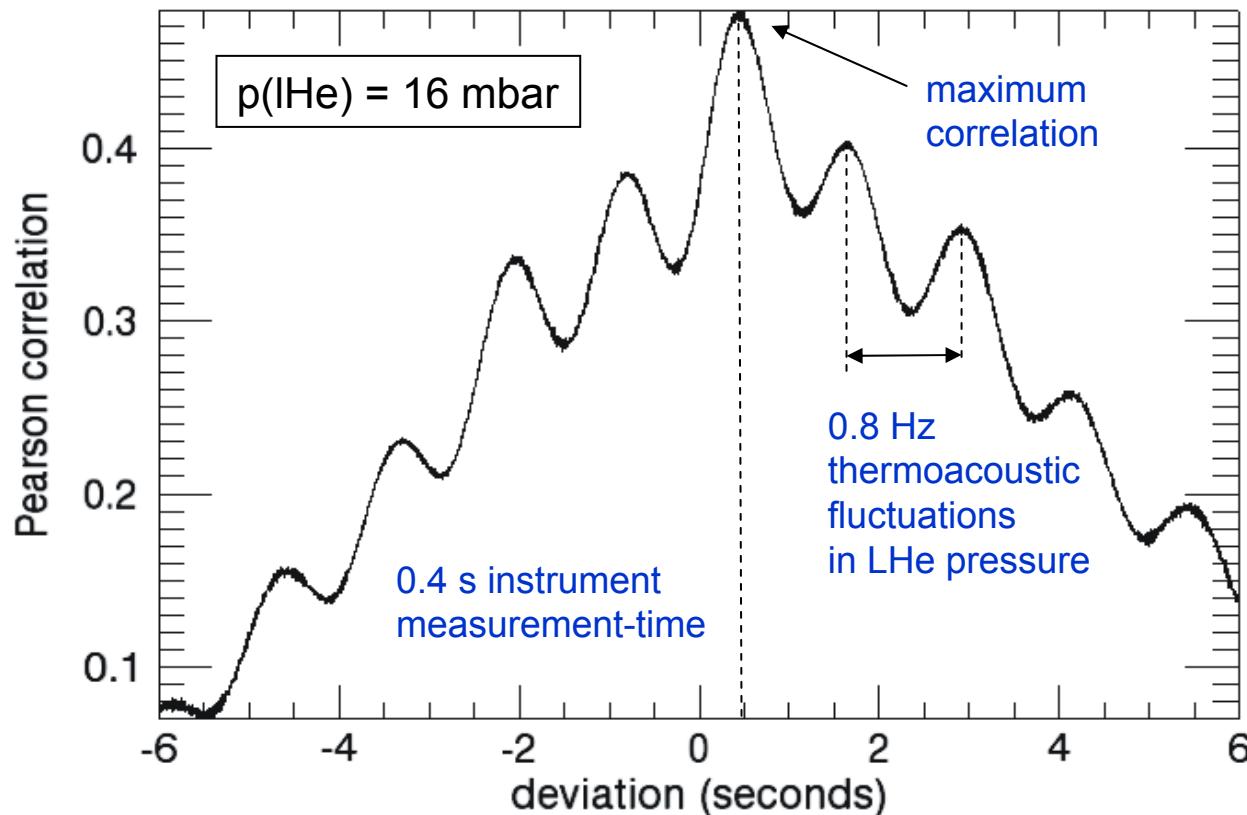




Integrated Fast Fourier Transform from microphonics spectra

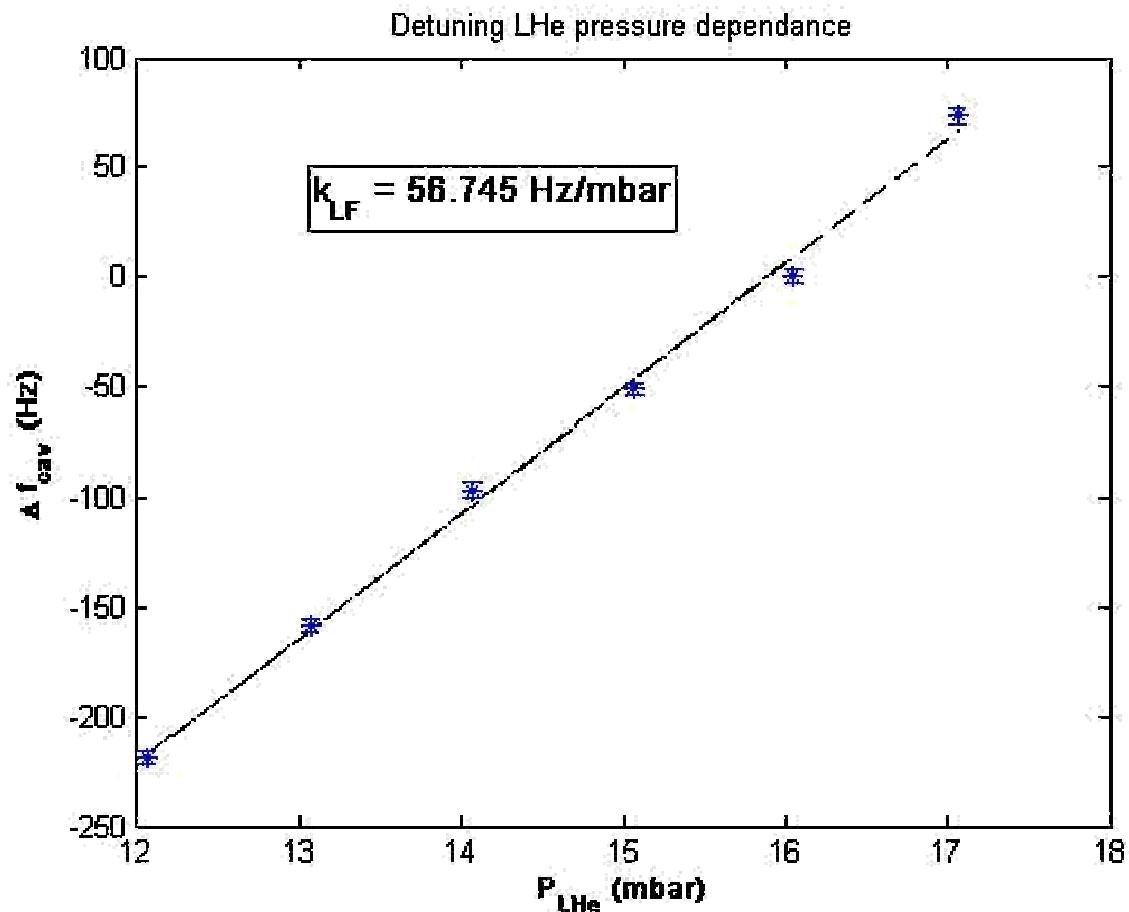


Cross-correlation between pressure in liquid helium bath and phase error

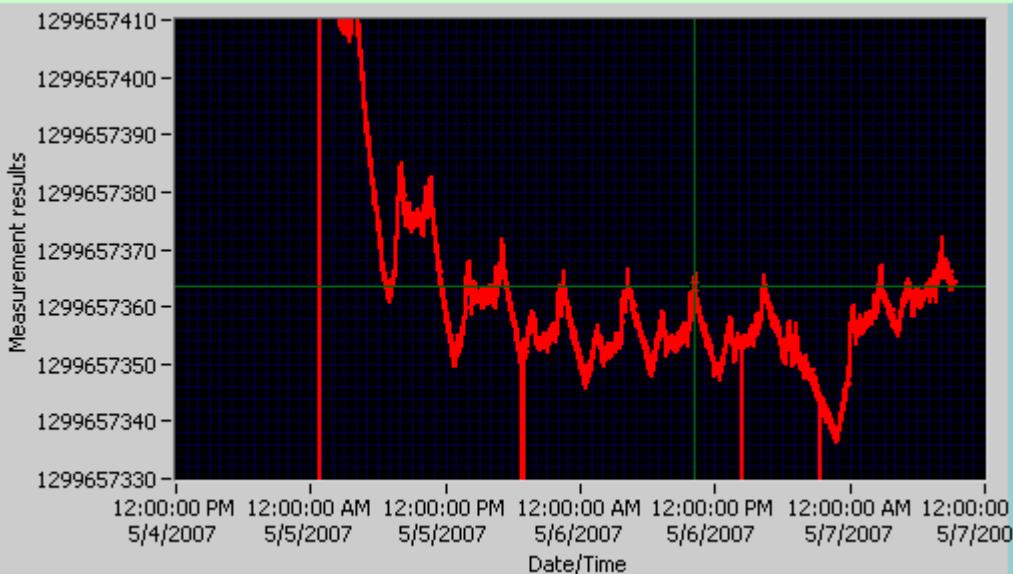


- Aiming at microphonics rms value < 1 Hz

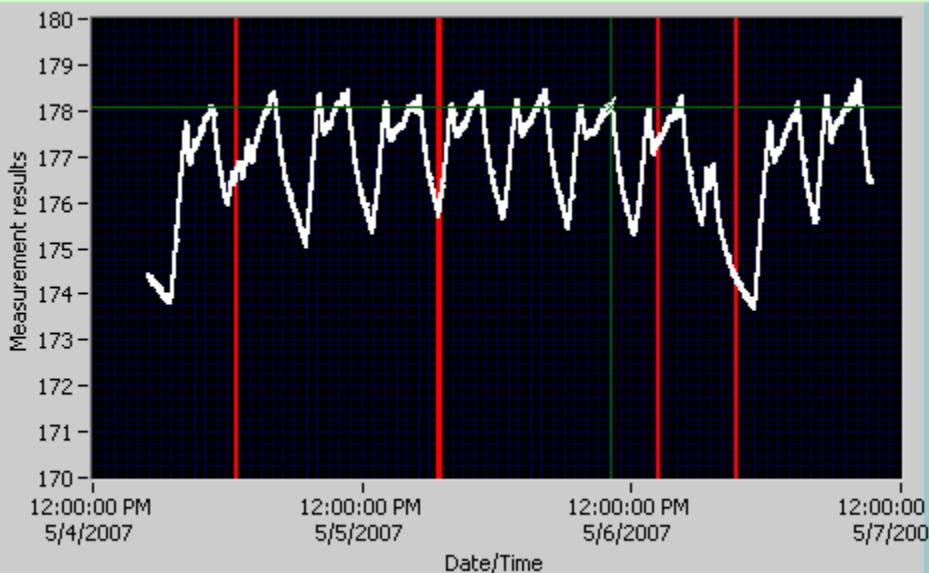
Importance of pressure stability:
1 mbar pressure change shifts cavity resonance by several bandwidths

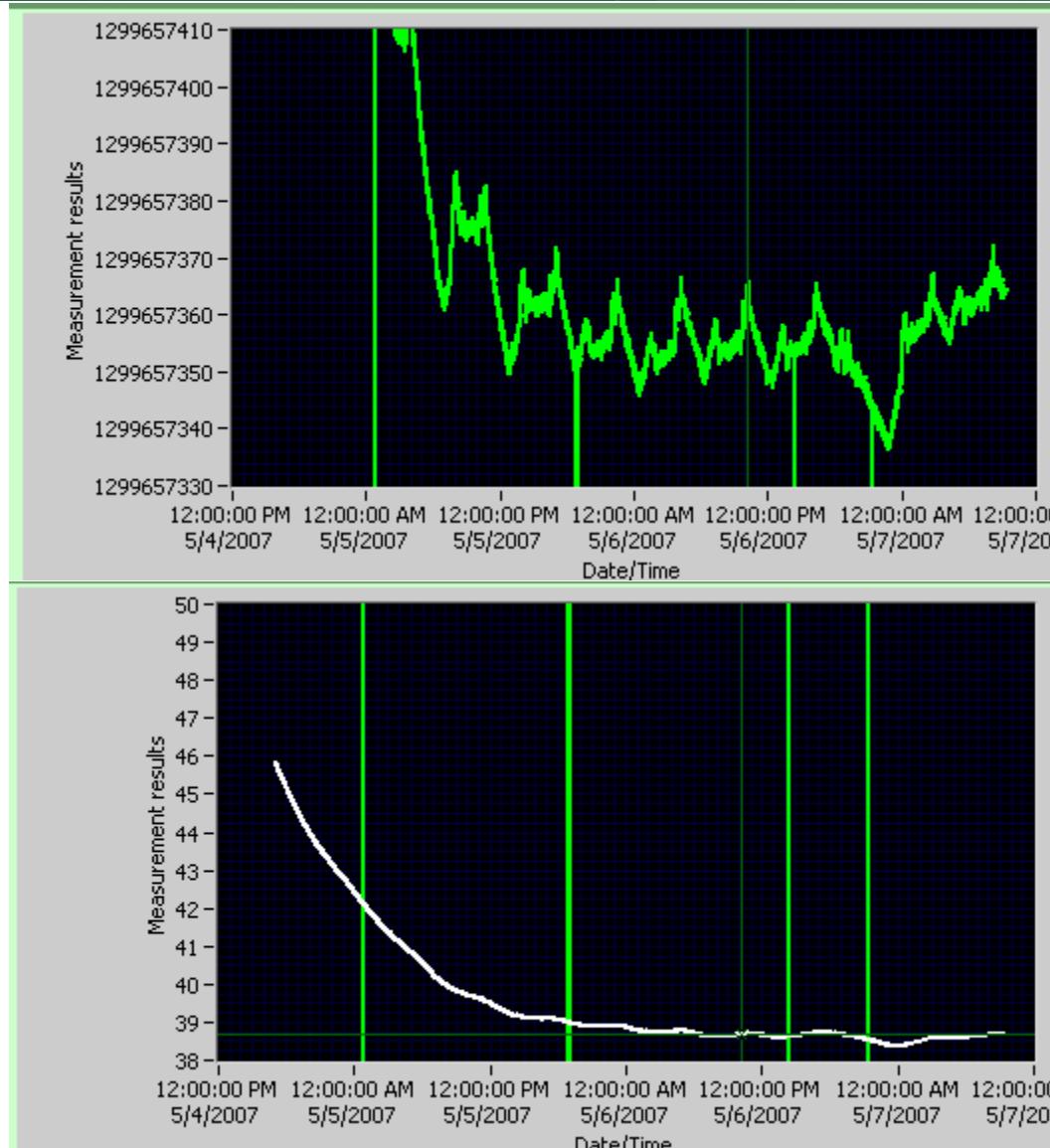


Pressure stability in HoBiCaT now better than 30mbar pk-pk



Observed strong correlation between **cavity resonance frequency** (upper picture) and cryogenics parameters, here a badly coupled part of the liquid nitrogen shielding



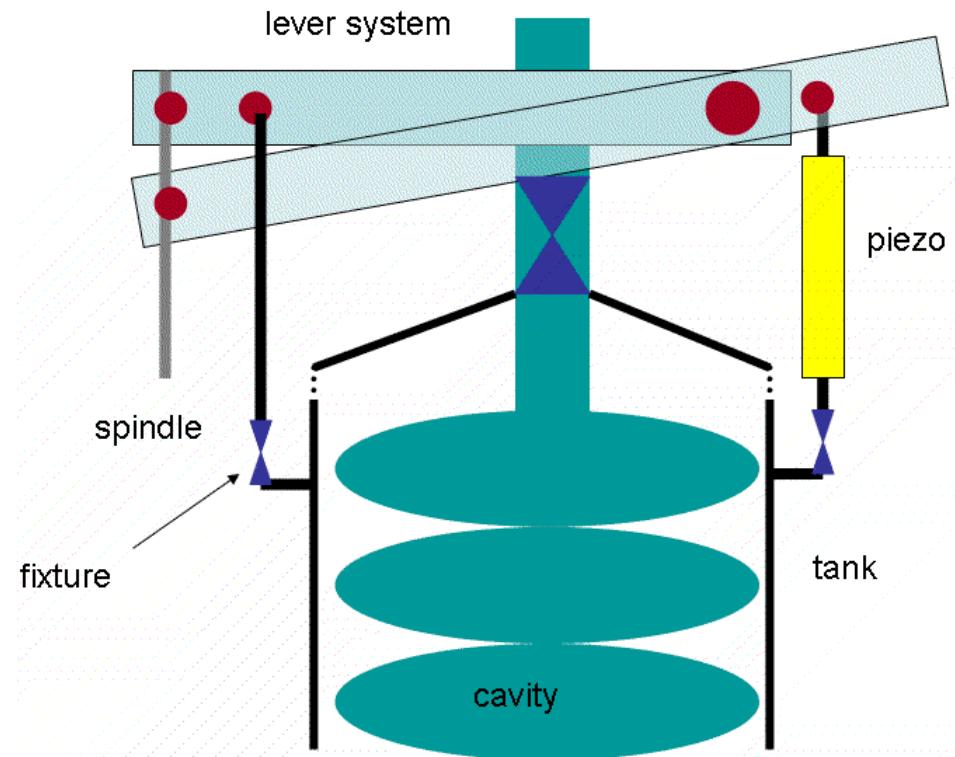
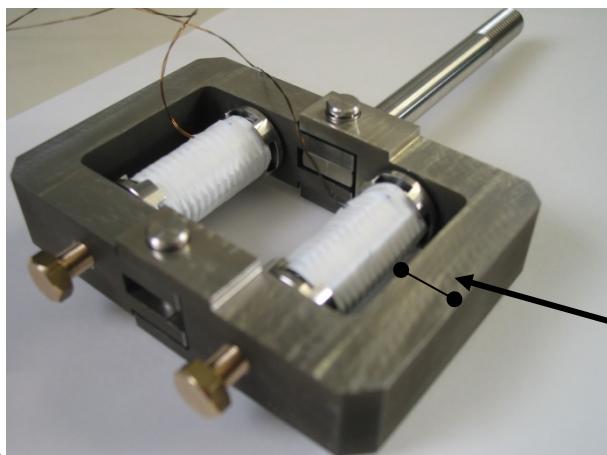
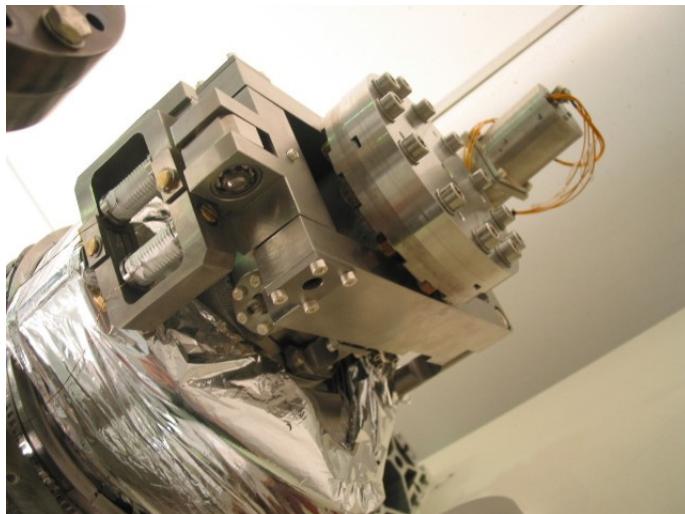


Strong correlation
between
**cavity resonance
frequency** (upper picture)
and cryogenics
parameters, i.e.
the slowly relaxing
temperature at a badly
thermally coupled stepper
motor tuner

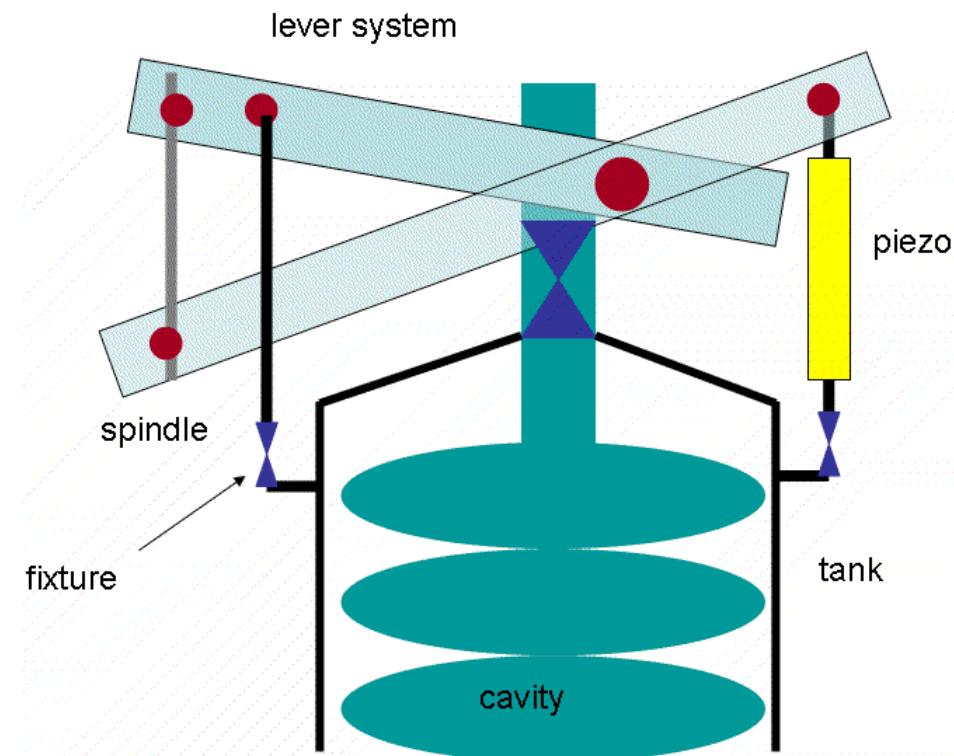
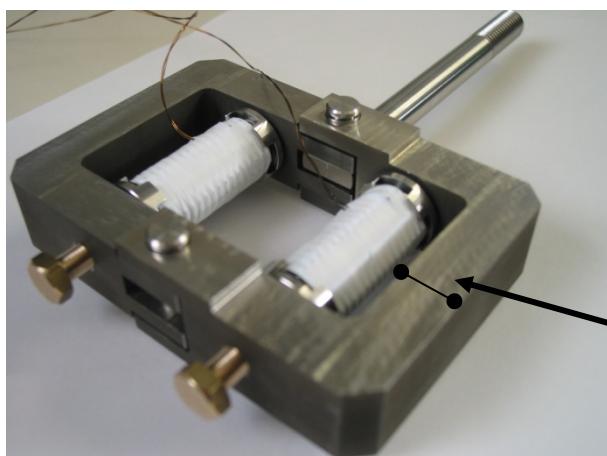
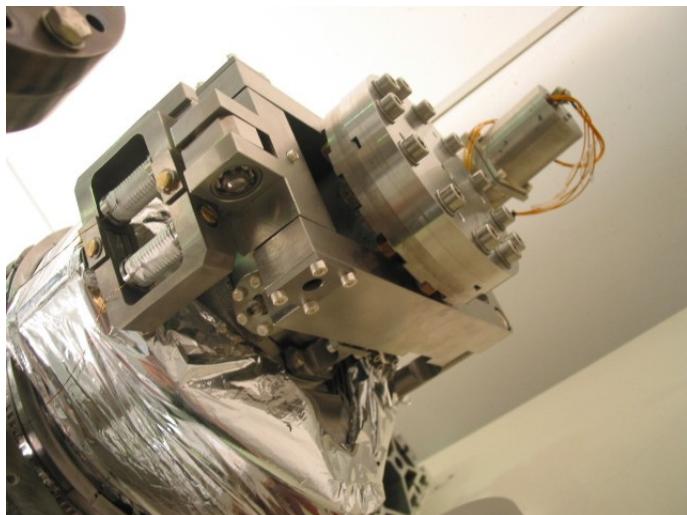
Requirements for the tuner

- Tuning Range
- Hysteresis
- Group delay small
- High Stiffness
- Boring transfer function
- Resolution

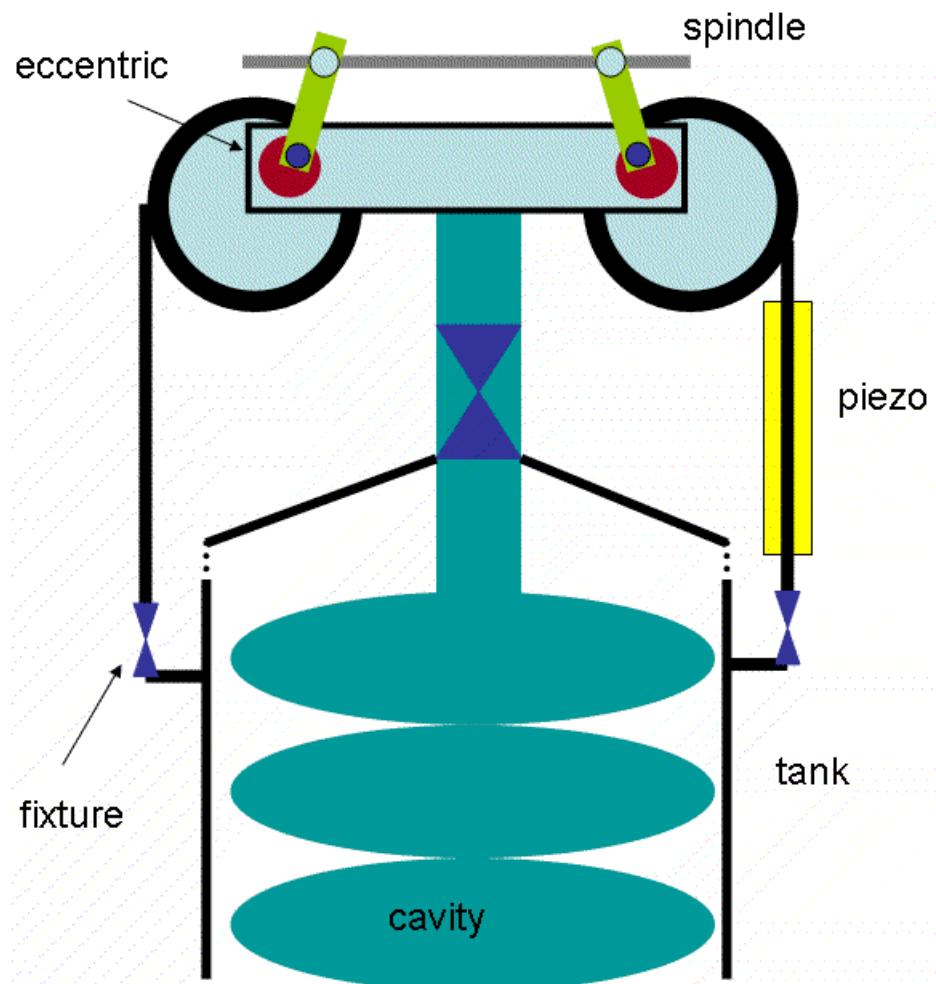
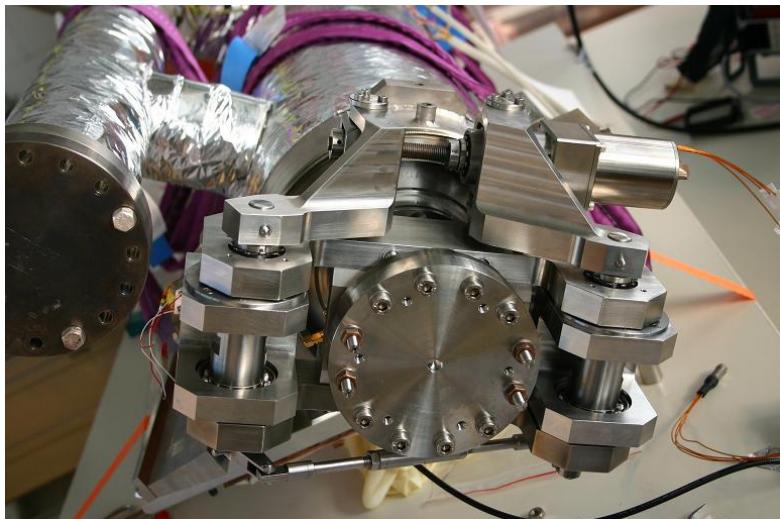
Saclay I tuner



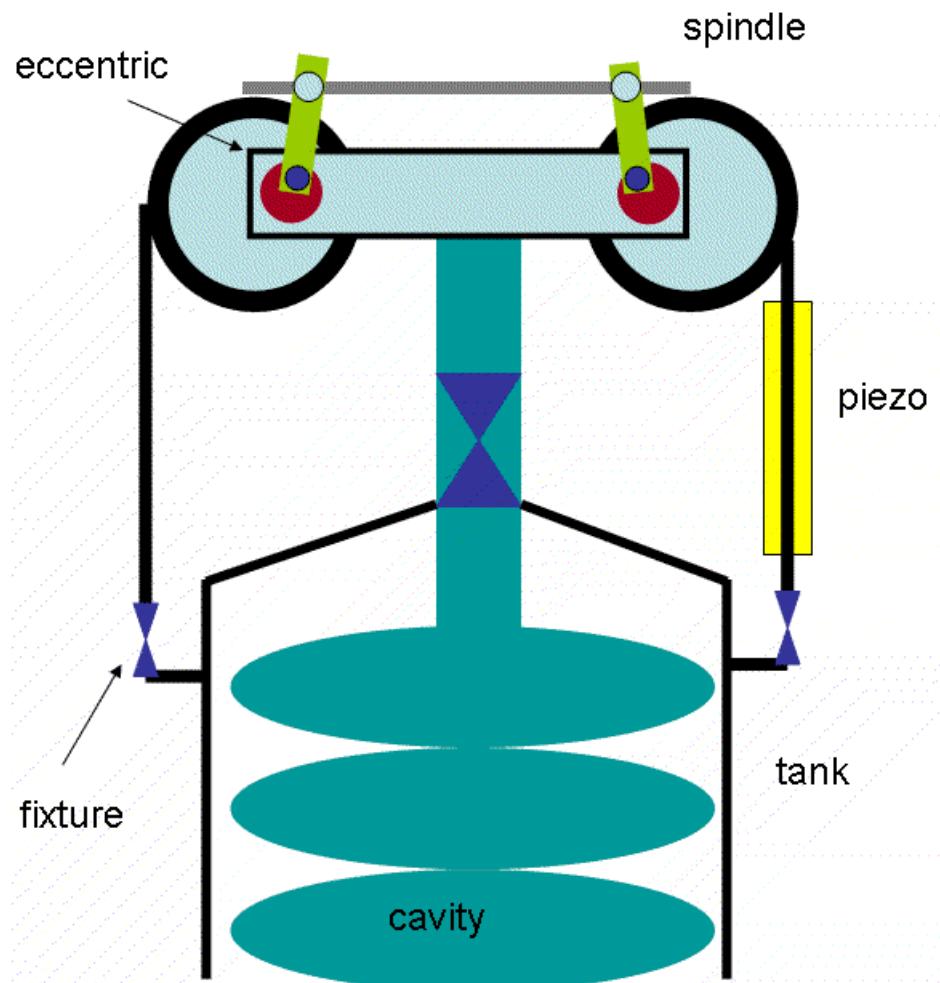
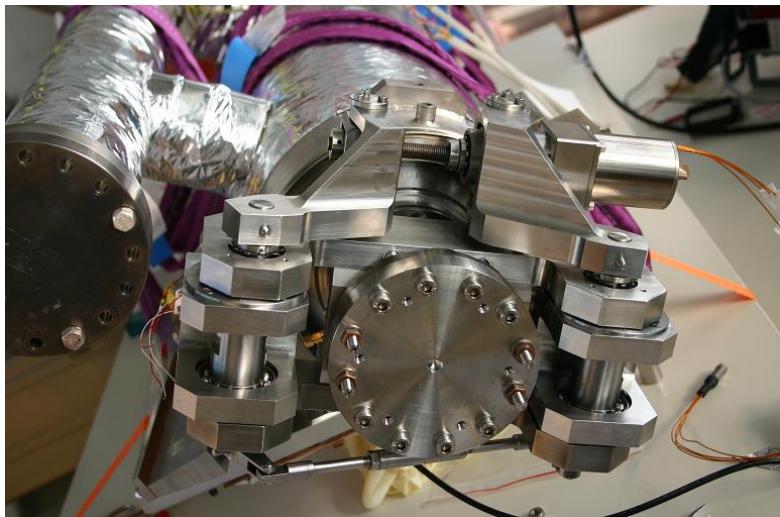
Saclay I tuner



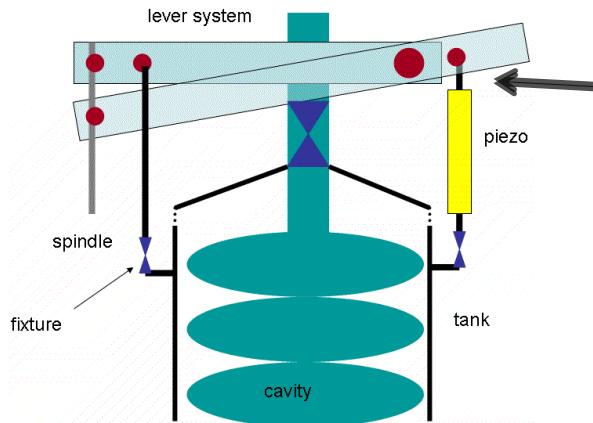
Saclay II tuner



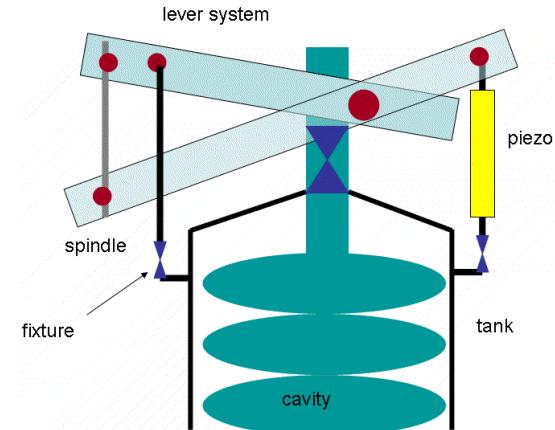
Saclay II tuner

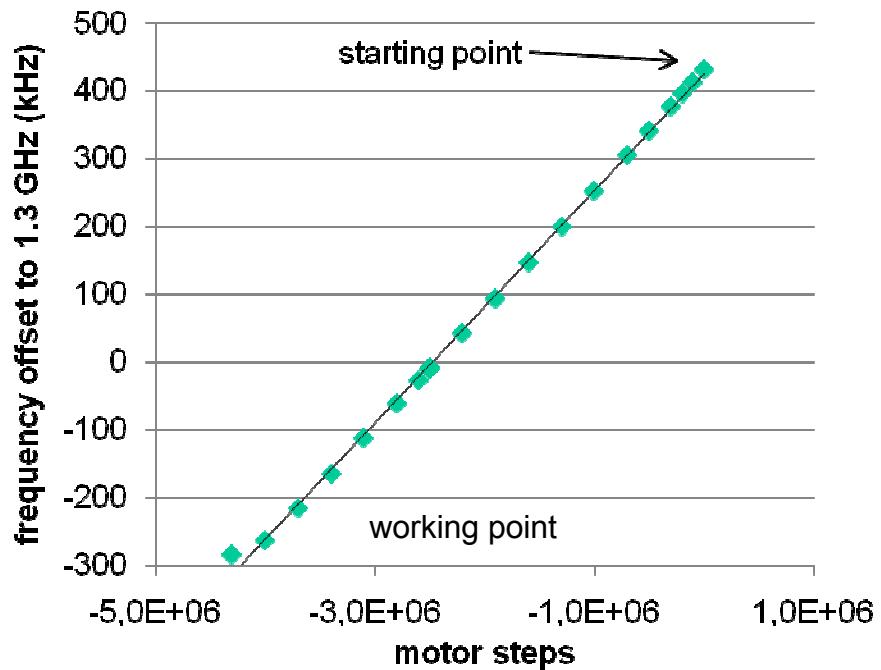
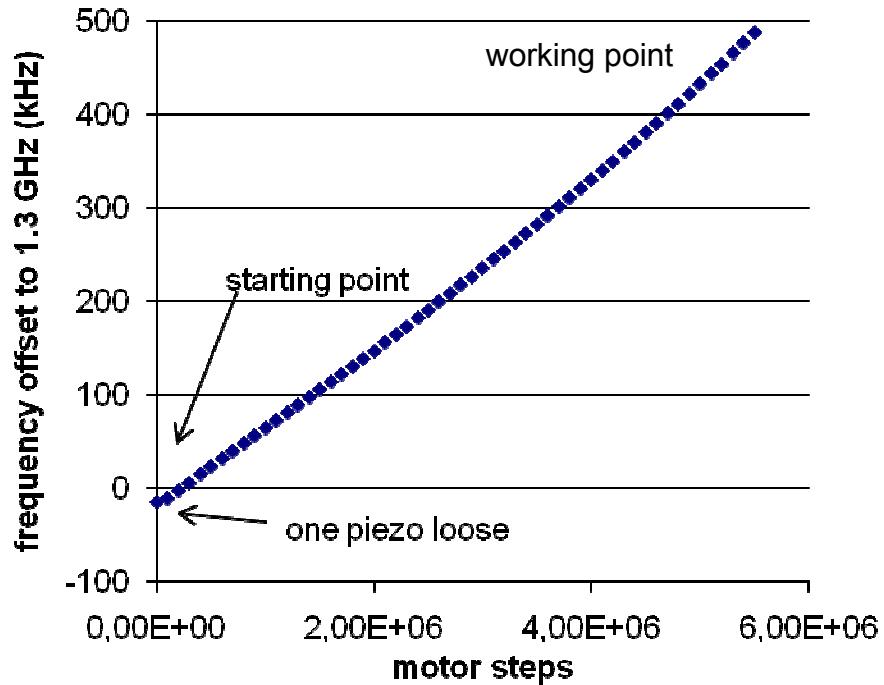


	Saclay I	Saclay II
Tuner driving-force on cavity	Compression	Expansion
Required pre-load at cavity assembly	Pre-stress	Pre-strain
Pre-stress on piezo when tuning to 1.3 GHz	released	increasing
Necessary pre-detuning on cavity assembly	+ 600 kHz (Kreps et al. ACONF98)	est.: -500 kHz



Pre-stress released
upon tuning to 1.3 GHz

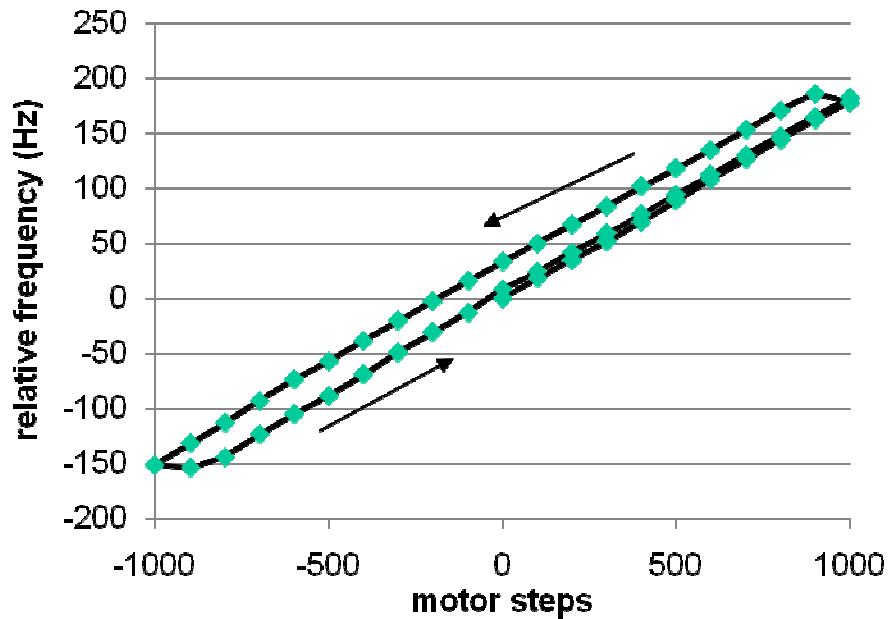


Saclay I

Saclay II


	Saclay I	Saclay II
transmission	0.176 Hz / step	0.09 Hz / step
tuning range	750 kHz	500 kHz
spindle movement		40 mm

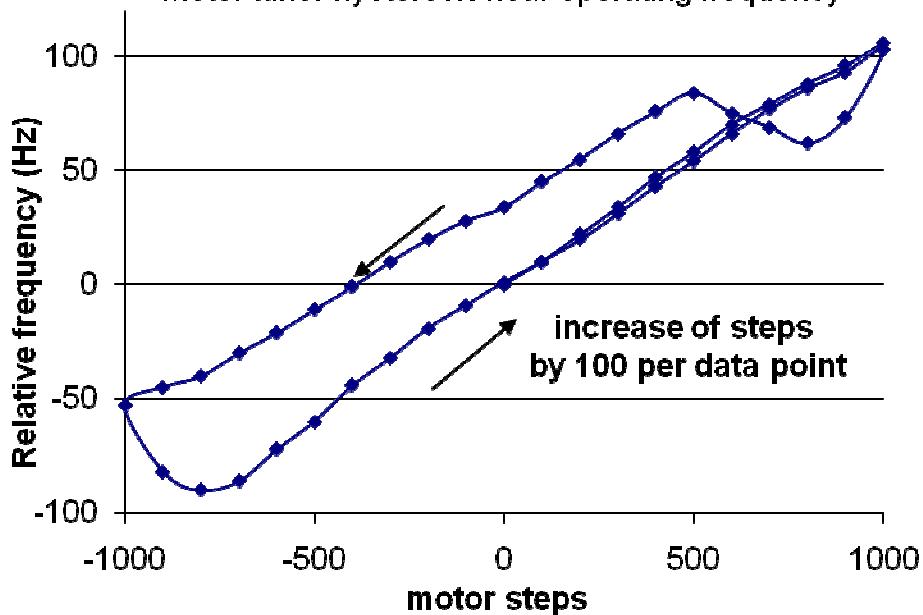
Saclay I

Motor tuner hysteresis near operating settings



Saclay II

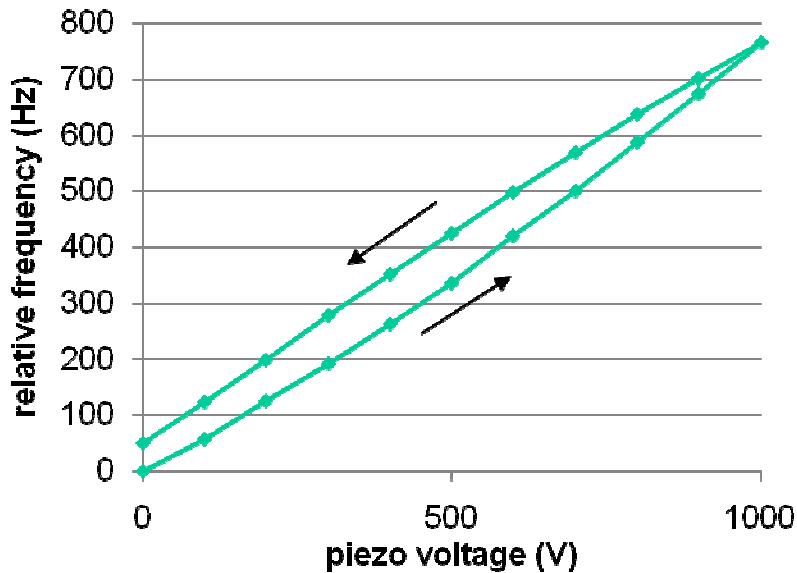
Motor tuner hysteresis near operating frequency



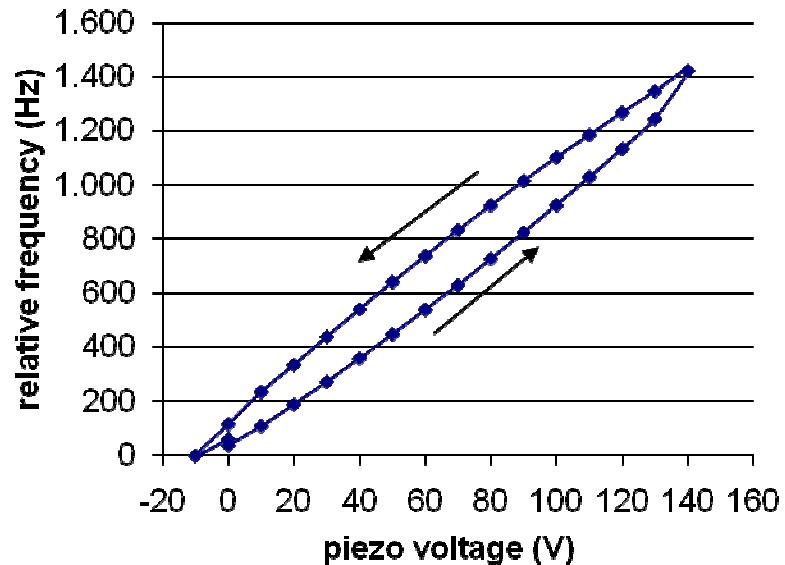
	Saclay I	Saclay II
Maximum remanence	30 Hz	55 Hz
Backlash	No	Yes *
Coercitive Steps	180	350 @ lower end 500 @ higher end

* Effect smaller towards lower frequencies

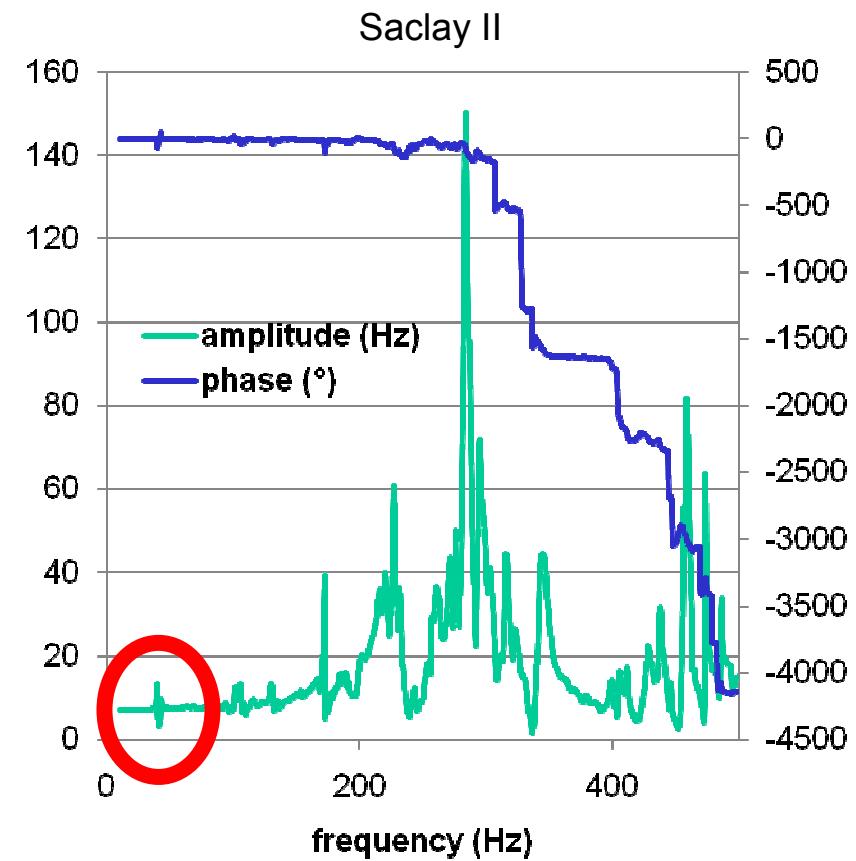
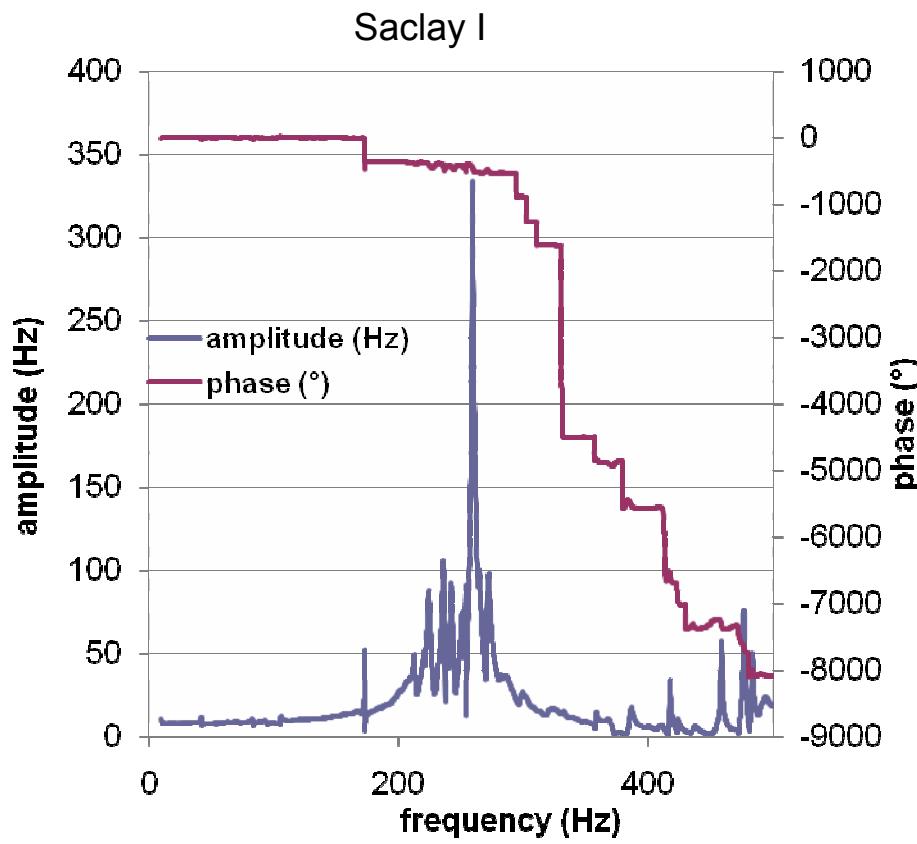
Saclay I (high voltage piezo)



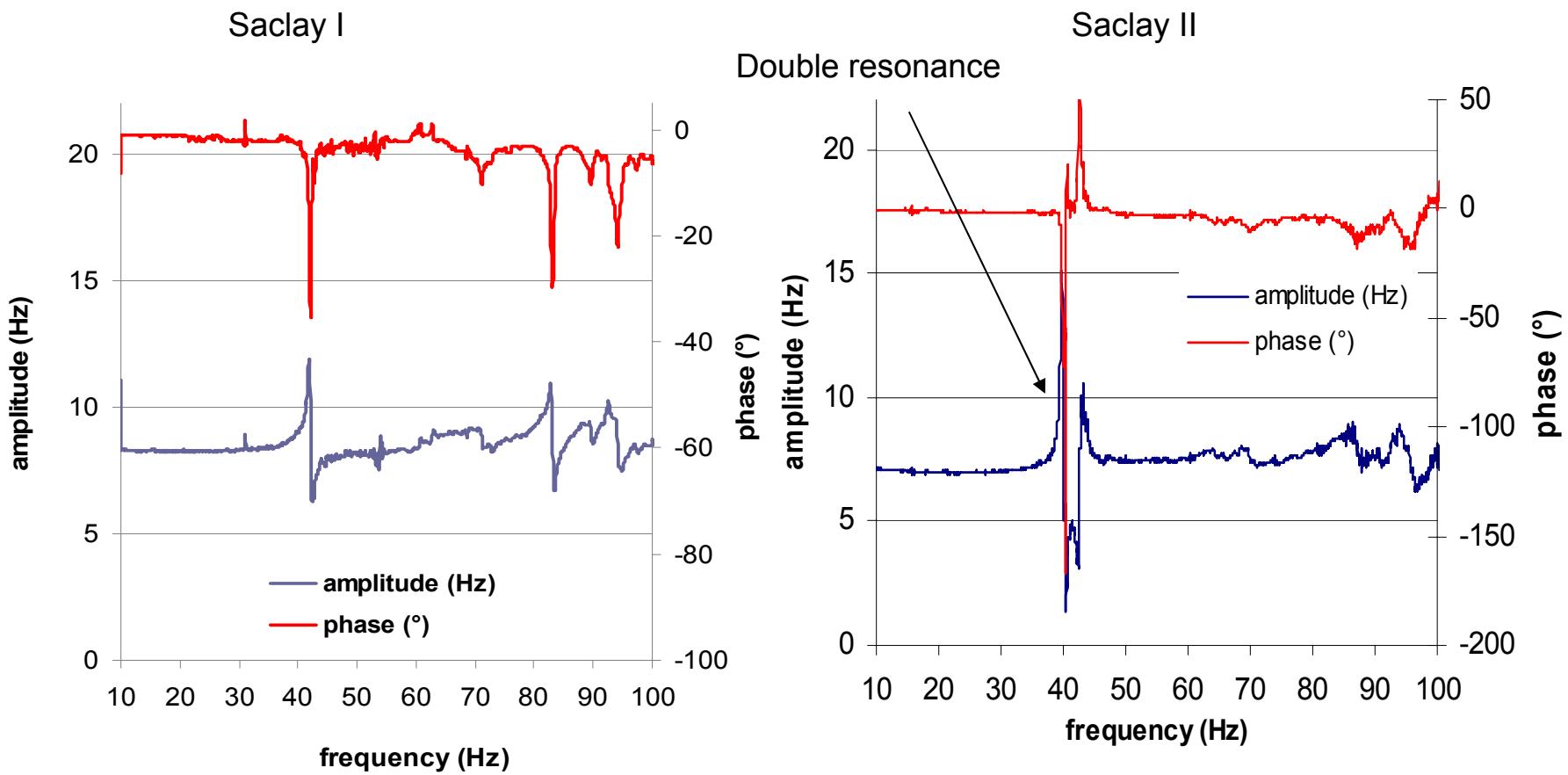
Saclay II (low voltage piezo)



	Saclay I	Saclay II
Piezo type	High voltage (0 ... 1000 V)	Low voltage (0 ... +150 V)
Tuning range	750 Hz * (870 Hz at operating cond.)	1420 Hz
Tuning coefficient	0.75 Hz / V * (0.87 Hz / V)	9.44 Hz / V
Maximum remanent frequency	100 Hz	200 Hz
Maximum coercitive piezo voltage	120 V	20 V



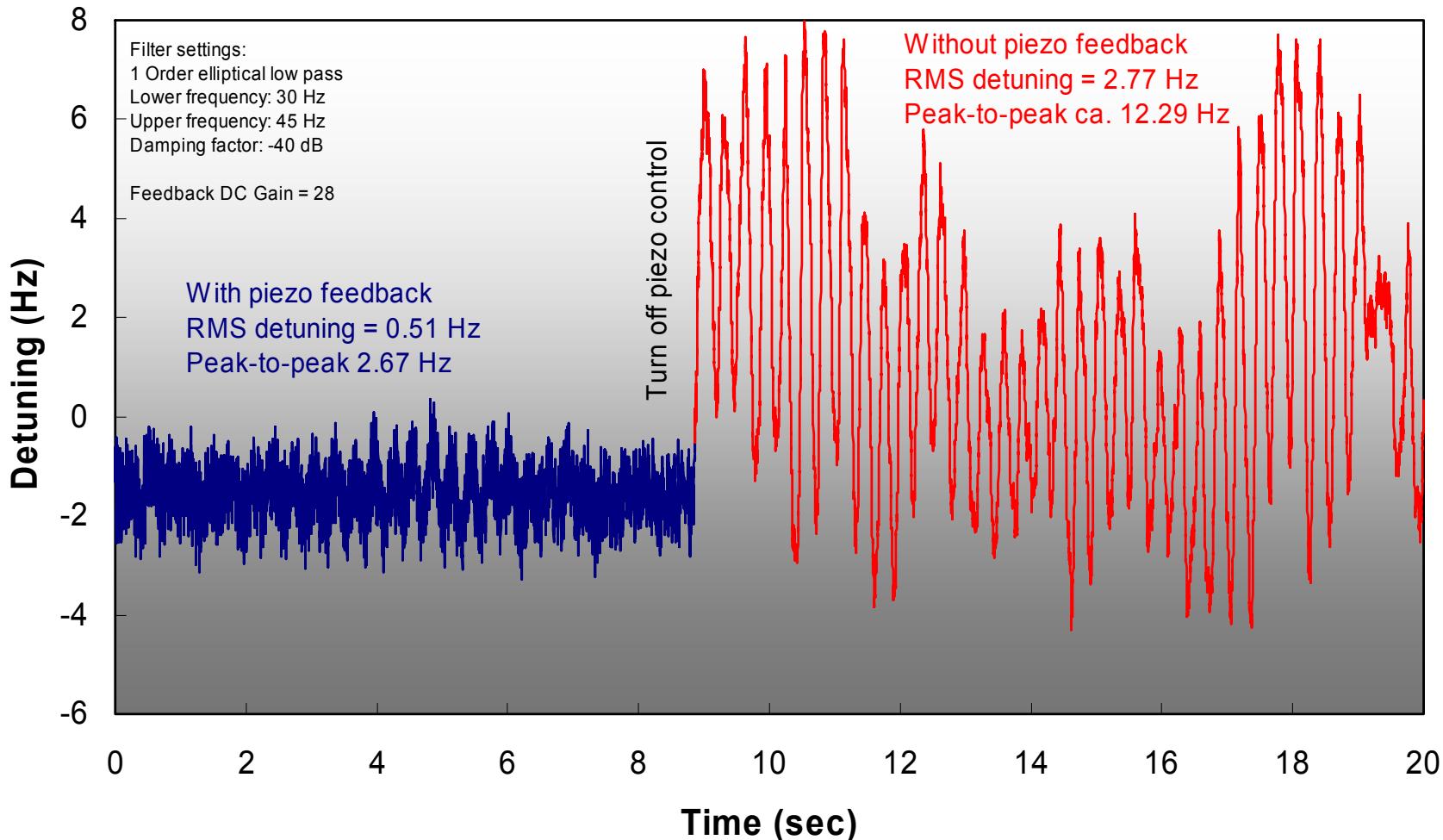
	Saclay I	Saclay II
Excitation amplitude	22.5 Hz	19 Hz
Maximum cavity response	340 Hz	150 Hz

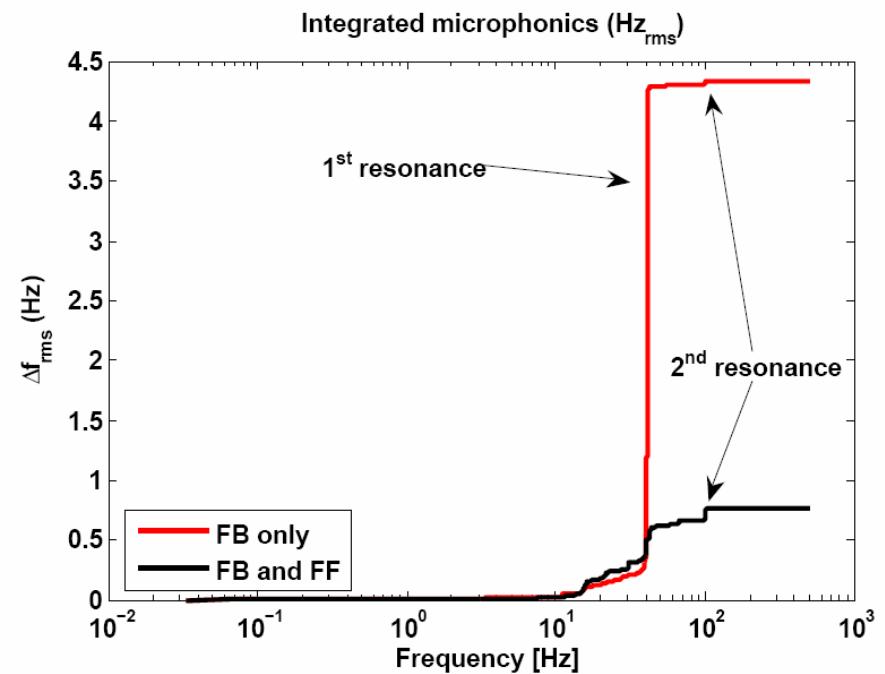
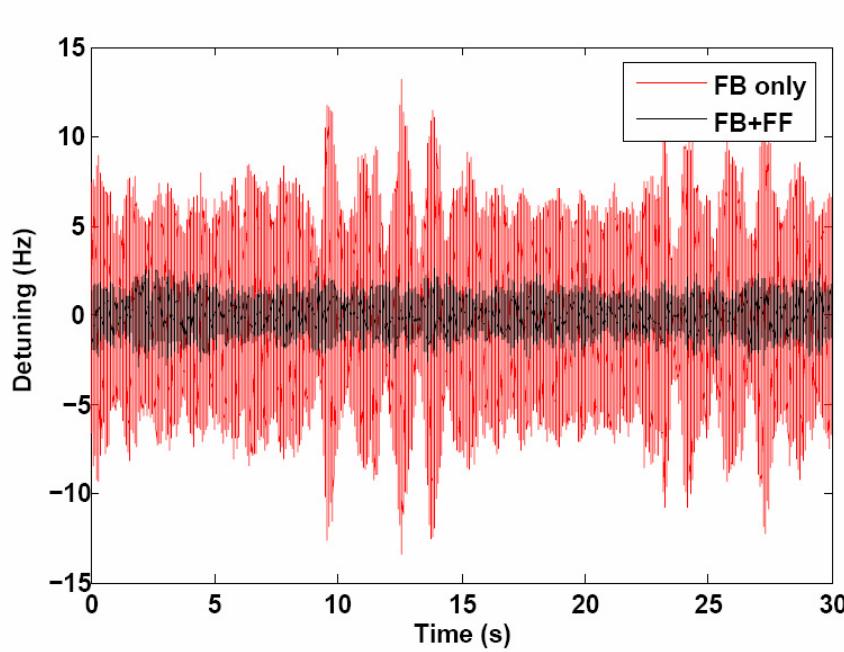


	Saclay I	Saclay II
Group delay at low frequencies	361 μ s (290 μ s for starting position)	150 μ s
Lowest resonance at 40 Hz	single	double structure

Overview of tuner properties what works, what must be improved

Design	Saclay I	Saclay II
Motor tuning range	750 kHz	500 kHz
Motor hysteresis	better	
Piezo tuning range	840 Hz	1420 Hz
Group delay	360 μ s	150 μ s
Stiffness	lower	higher
		favored





Δf (rms, feedback) = 4.33 Hz,
maximum=13.4 Hz

Δf (rms, feedback+FF) = 0.77 Hz,
maximum at 2.9 Hz

- Measured microphonics in HoBiCaT, 1-3 Hz rms, 10-15 Hz pk-pk
- 50 % is due to LHe bath pressure → feedback possible
- → Stability of liquid Helium pressure critical for microphonics
- Analyzed two tuners for suitability of compensation
- Pro Saclay I: motor control, pro Saclay II: piezo control
- Motor control for Saclay II needs improvement
- Microphonics reduction demonstrated by factor 3

Bessy:

Axel Neumann
Jens Knobloch
Wolfgang Anders
Michael Schuster
Sascha Klauke

Saclay:

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Guillaume Devanz
Eric Jacques
Pierre Bosland

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Rolf Lange
Kay Jensch
Clemens Albrecht
Lutz Lilje